

MERcury Intense Target (MERIT) Experiment – *or nTOF-11*



*Mercury fountain, Funtació Joan
Miró, Barcelona - Spain*

Experiment overview & Safety Issues

Contact persons:

[Ilias Efthymiopoulos](#)

[Adrian Fabich](#)

Outline

Overview

- Introduction
- The Experimental setup
- Safety Issues
 - Mercury loop
 - Radiation
 - Cryogenics
 - Solenoid – power supply
 - Access
 - Installation
- Schedule
- Next steps wrt safety

The MERIT Experiment (1/2)

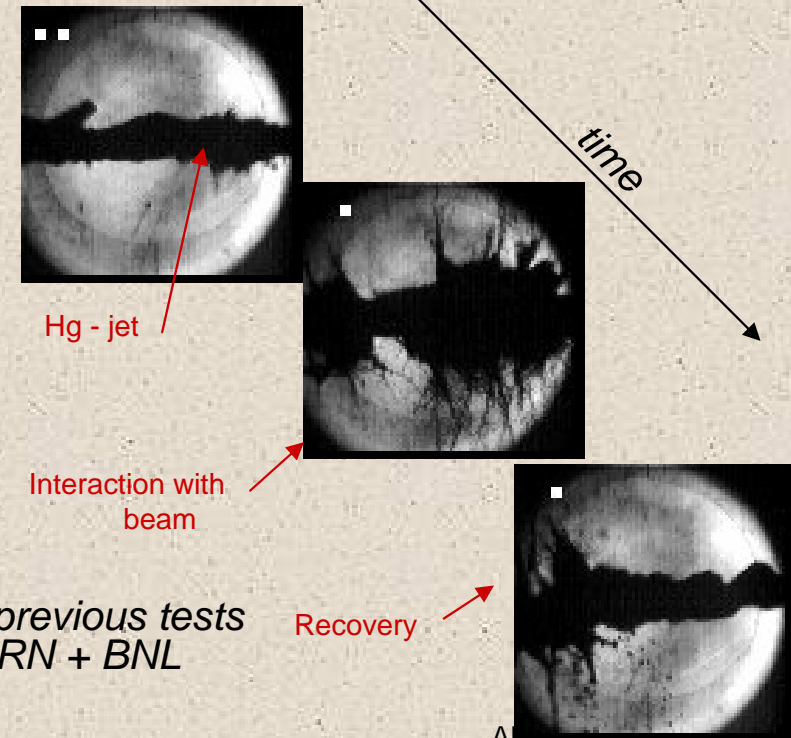
We propose to perform a **proof-of-principle test of a target station** suitable for a Neutrino Factory or Muon Collider source using a 24-GeV proton beam incident on a target consisting of a **free mercury jet** that is inside a **15-T capture solenoid magnet**.

Proposal submitted to INTC – May 2004

Experiment approved as nTOF-11 → **MERIT**

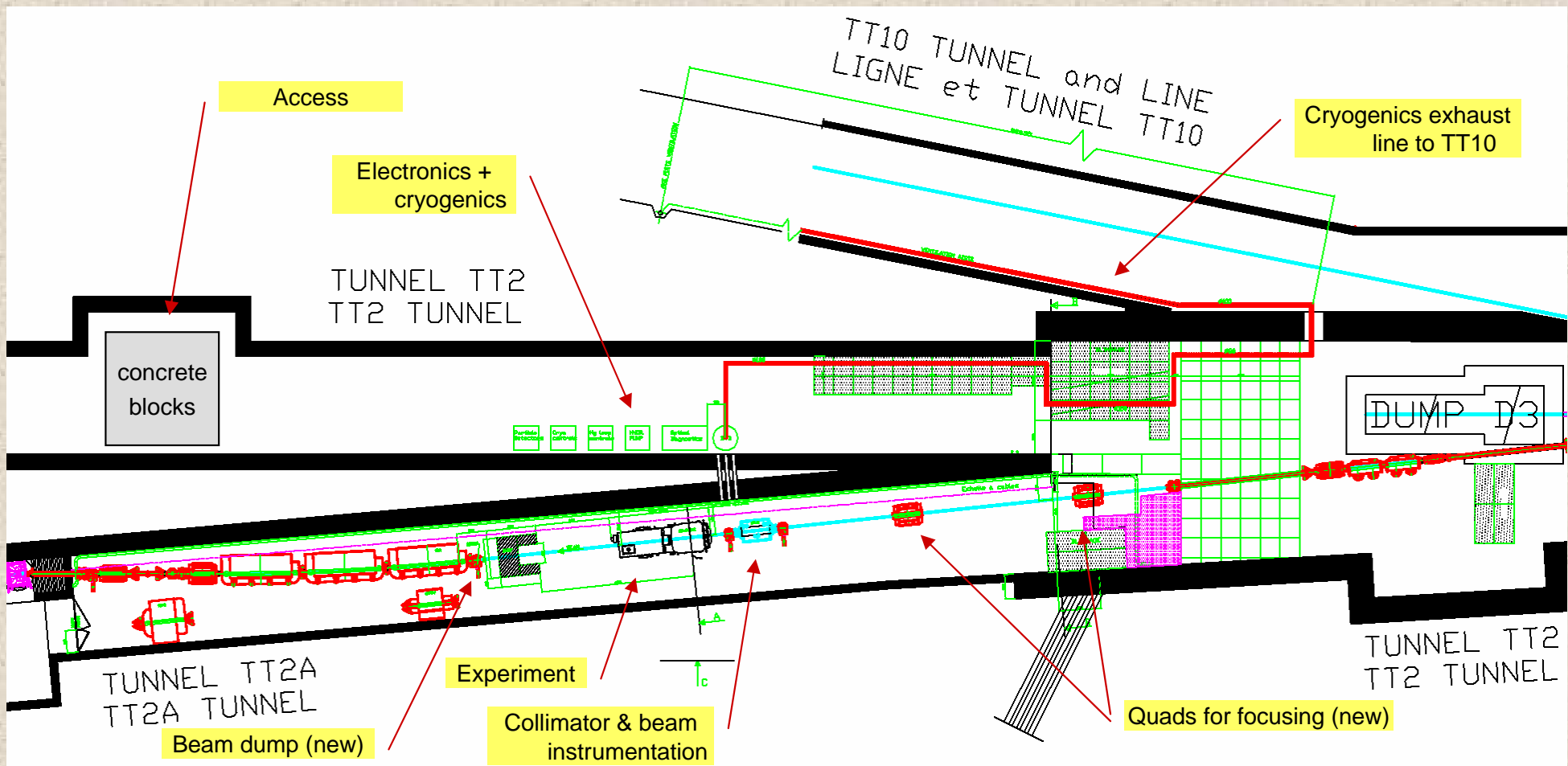
Target

- 1-cm diameter Hg jet, $v \cong 20\text{m/s}$
- PS Proton beam: 24 GeV/c
 - 4 bunches of 7×10^{12} protons each (max), spaced between 0.5÷2 usec
 - ~100 (HI) pulses in total
- Meson collection using a 15-T solenoid

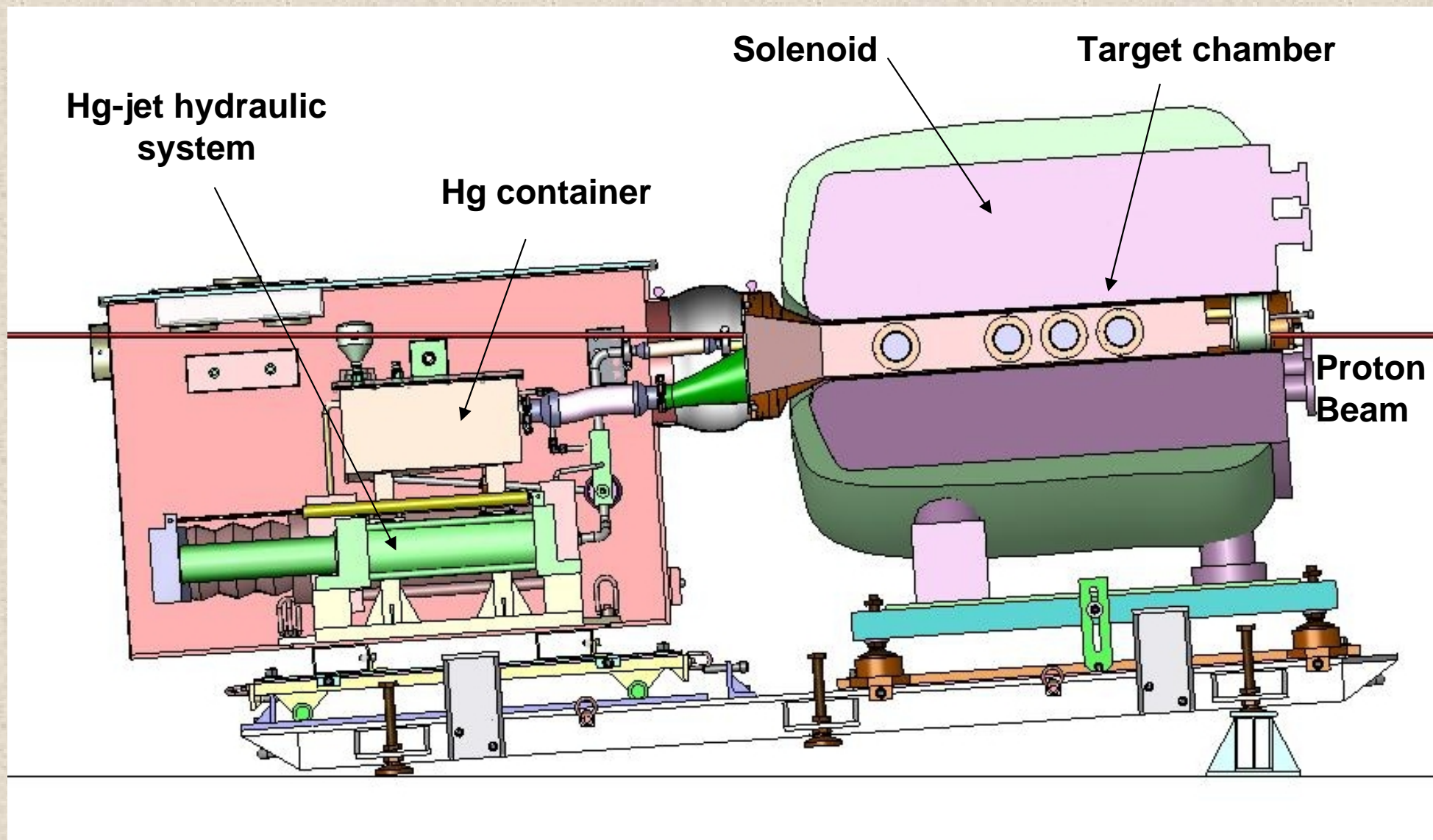


The Experimental Setup (1/2)

- Located in the **TT2A tunnel** upstream of the nTOF target
- **Data taking:** two-weeks at the PS startup in 2007 – second slot later as reserve



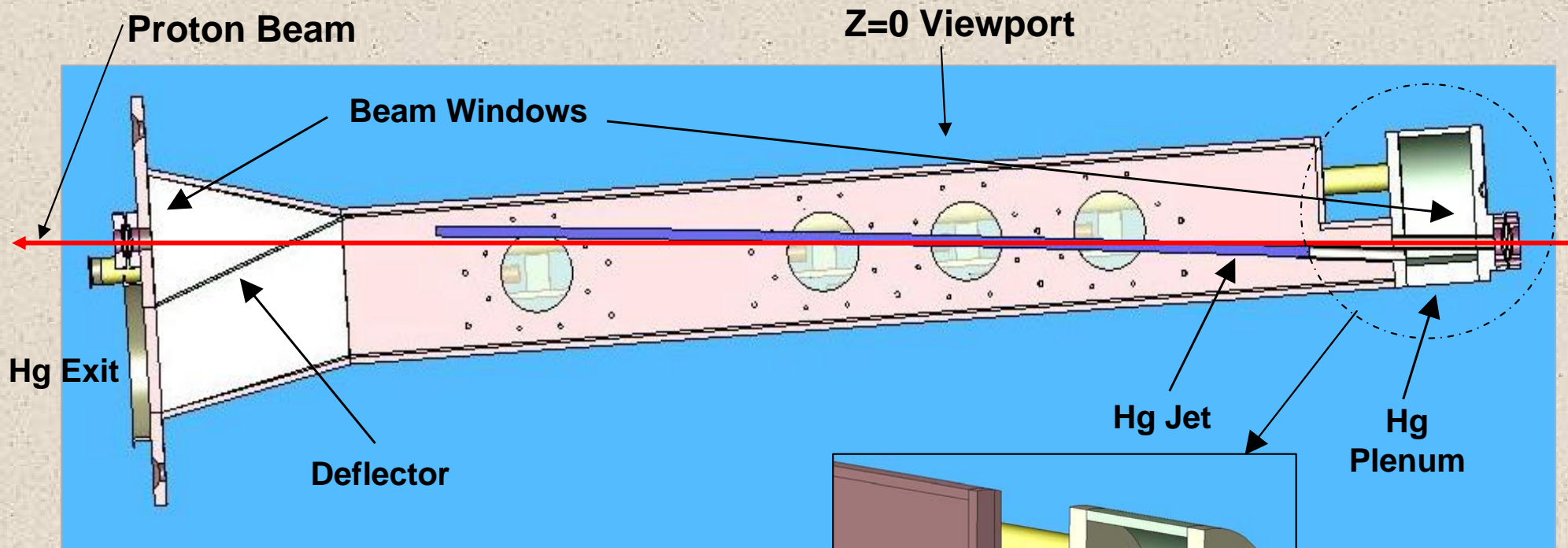
The Experimental Setup (1/2)



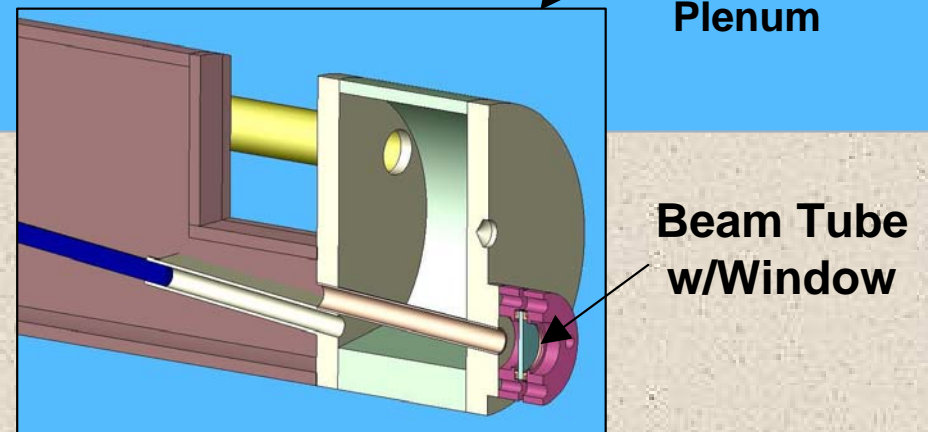
The Experimental Setup (2/2)

Hg loop - Target volume

- The beam hits the jet at $z=0$ position at an angle of 33mrad



- Hg jet at 100mrad angle with magnet axis
- Proton beam at 67mrad angle with the magnet axis



Safety issues

□ Several safety issues discussed

□ No show-stoppers
 ■ Decision

□ Memos on
 ■ <http://pr>

□ Items to include
 ■ ISIEC for

 ■ Beam A

Home

Up

Radiation Safety

Fire&Materials

Mechanics

Chemicals

Cryogenics

SAFETY

- ▶ 3rd Feb. [Safety Review - Announcement](#)
- ▶ General safety hearing, March 04, [minutes](#)
- ▶ General safety hearing, December 2003, [minutes](#)

presentation [Activation Tunnel \(HK\)](#)

▶ **LIST OF SAFETY PERSONS CONCERNED**

SAFETY CONTACT PERSON FOR ALL MATTERS:

Bruno PICHLER tel: 16 0889

	Responsible	tel.
DSO of AB	Paolo CENNINI	16 4625
FGSO of PH	Olav ULLALAND	16 33 42
General Safety	Bruno PICHLER	16 0889
Radiation	Thomas OTTO	16 0648
Gas and Chemicals	Jonathan GULLEY	16 0890
Electricity	Fritz SZONCSO	16 4030
Emergency stops		
Magnetic Field		
Laser	Fabio CORSANEGO	16 4548
Fire		
Material	(material also J.Gulley)	
Mechanical safety	Alberto DESIRELLI	16 0638
--- --- --- --- ---	Maurizio BONA	
Cryogenics	Gunnar LINDELL	16 0784

Safety issues (2/8)

Mercury Handling

- Keep volume to strict minimum
- All operation by experts – ORNL
 - All mercury comes from US and goes back to US (ORNL)
- Primary / Secondary container configuration
- No break of the primary container whatsoever during the lifetime of the experiment at CERN
- All measures for personnel protection will be taken



ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

MEMORANDUM

FROM : J. Gulley (SC/GS)
TO : A. Fabich (AB/ATB)
CC : P. Cennini (AB/ATB); T. Otto (SC/RP); B. Pichler (SC/GS); R. Trant (SC/GS).

Subject : Proposed use of mercury at CERN in the Experiment TT2A

This memorandum outlines some guidelines and preliminary remarks with respect to the proposed use of mercury in the TT2A experiment at CERN.

- i.) The amount of mercury employed in the experiment should be kept to a minimum.
- ii.) On arrival at CERN the mercury will be stored in a dedicated place (e.g. the chemical laboratory 3/1-031).
- iii.) Use the type of container recommended by the manufacturer. Inspect containers for leaks before handling. Secondary protective containers must be used when this material is being carried. Label containers and keep them tightly closed when not in use. Use corrosion-resistant transfer equipment when dispensing.
- iv.) A safe means of filling the system should be proposed (e.g. by vacuum pump).
- v.) The leak-tightness of the closed system used for the experiment must be verified before operation and after any intervention on the system which risks to impair the leak-tightness.
- vi.) Mercury monitoring devices which continuously measure the concentration of mercury in the surrounding air are to be employed at strategic points (inside and outside of the containment that will enclose the apparatus) to give an early warning of a leak or loss of containment. All mercury monitors must be calibrated according to the manufacturer's instructions and give an alarm sufficiently below the exposure limits (i.e. $VME^1 = 0.05 \text{ mg/m}^3$, $VLE^2 = 0.4 \text{ mg/m}^3$). Any alarms generated must be promptly dealt with.
- vii.) Appropriate personal protective equipment, ppe (e.g. lab coat/coveralls, gloves, visor, safety goggles, boots, full-face respiratory equipment), must be made available for all persons who risk to come into contact with mercury during an intervention on the system or during an emergency. N.B. The minimum requirements for ppe must be defined based on the measured concentration and the activity in a similar way to the requirements laid down for the TTF Experiment. A portable mercury monitor is also deemed necessary. The type of gloves and the mercury vapour cartridge used in the respiratory protection must be specified. Cartridges and gloves must be kept outside of the immediate area where the mercury is used and must be changed on a regular basis. Respiratory protection is to be used only for work of short duration (e.g. filling, replacement of filters) or in case of an emergency³.

¹ VME = valeur (limite) moyenne d'exposition.

² VLE = valeur limite d'exposition calculée sur une courte durée.

³ Respiratory protection using cartridges is only suitable for protection up to the maximum concentration of mercury specified by the supplier of the cartridge and respirator. Based on the measured concentration the degree of protection will have to be increased with an intervention by the CERN Fire Brigade required above a defined threshold. Whenever the concentration of mercury is unknown an air-supplied respirator must be used.

Safety issues (3/8)

Solenoid and Cryogenics

- Safety review foreseen on February 3rd

Reviewers:

■ Cryogenic experts:

- Goran Perinic
- Vladislav Benda

■ Cryogenics safety:

- Gunnar Lindell

■ Mechanical Safety:

- Benoit Delille
- Andrea Astone

- **Key issue:** exhaust line to TT10

26.10.2004/GL



Comments from CERN's Safety Commission concerning:

NEUTRINO FACTORY /TT2A CRYOGENIC INSTALLATIONS

- Supply of LN2 from a dewar installed outside between building 559 and 506.
- LN2 transfer line from the dewar to the magnet in TT2A.
- The magnet will contain 30 to 300 liters of LN2 (still not defined)

Documentation

1. Please provide P&ID's (Pipe & Instrumentation Drawing) for all the equipments, including date, version and drawing number.
2. Please provide a PFD (Process Flow Diagram) for all the different modes (filling, quenching, warming up etc).
3. Please provide a list of all safety valves, their position and their settings for all cryogenic equipment in this project.
4. The pressure vessels (magnet and dewar) and it's accessories shall be conform to Directive 97/23/EC (EC declaration plus manufacturing documents such as material certificates, welding procedure specification, method of welding, certification of welders, pressure tests etc). Please contact E. Jonker (SC/GS) directly in this matter.
5. Please provide the documentation for the safety valves as indicated in the Directive 97/23/EC. Safety valves are category IV.
6. Please provide the calculations for sizing the safety valves.
7. The dewar shall be conform with the applicable cryogenic standard (depending on size).
8. The cryogenic valves shall be conform with EN1626.
9. Complete documentation shall be provided for the instrumentation (manufacturer, model, operating range, maintenance etc)
10. Please provide implementation drawings of the dewar, the transfer line and the magnet.

Pressure build up

11. Please assure that there are safety valves wherever cold gas/liquid could be trapped: vessels & pipes between valves.
12. Please show that no liquid can be trapped in the valve when operating it (ball valves and gate valves).

Page 1(2)

Safety issues (4/8)

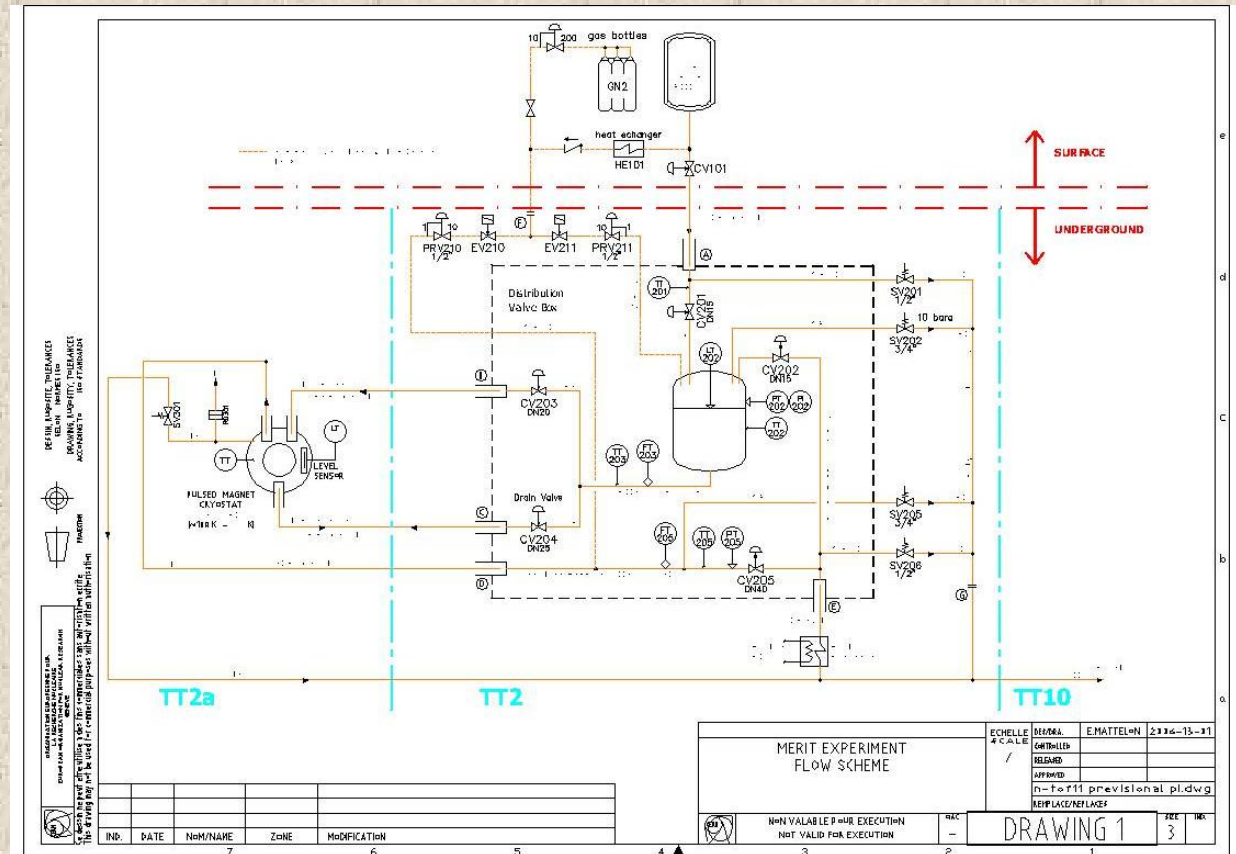
Solenoid and Cryogenics – Exhaust line to TT10

- Release of LN2 gas (through a heat exchanger) during the cooling down of the magnet
 - ~ 200 lt of LN2 ; ~1 lt activated – remnant from previous fill

- TT10 is the only ventilated tunnel close to the experiment
 - ~27'000 m³/h flow
 - release near bat 806

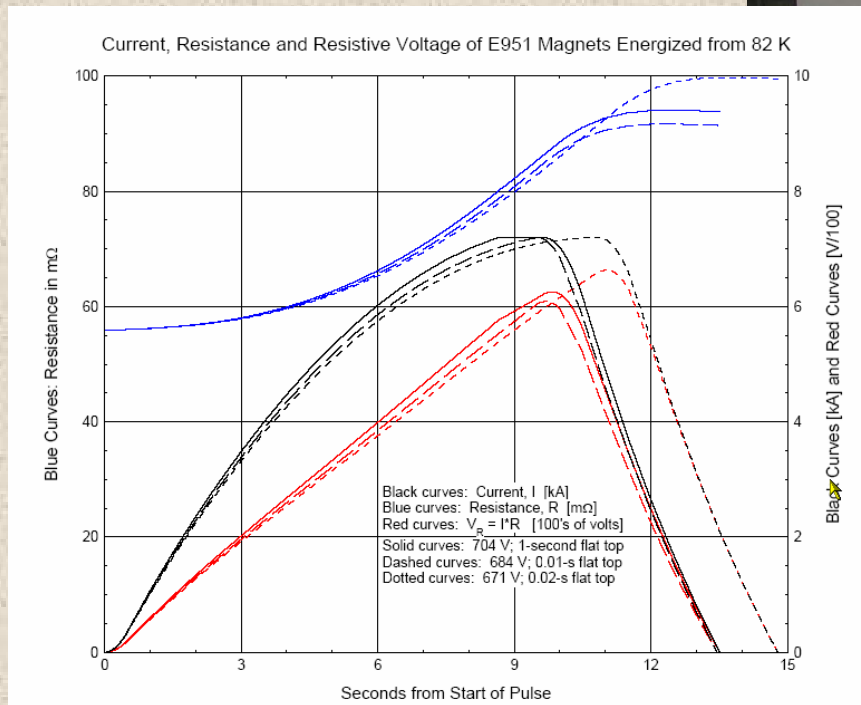
MERIT

- ~4400 m³/h
- Wait few min before refilling to reduce radiation levels



Safety issues (5/8)

Power supply

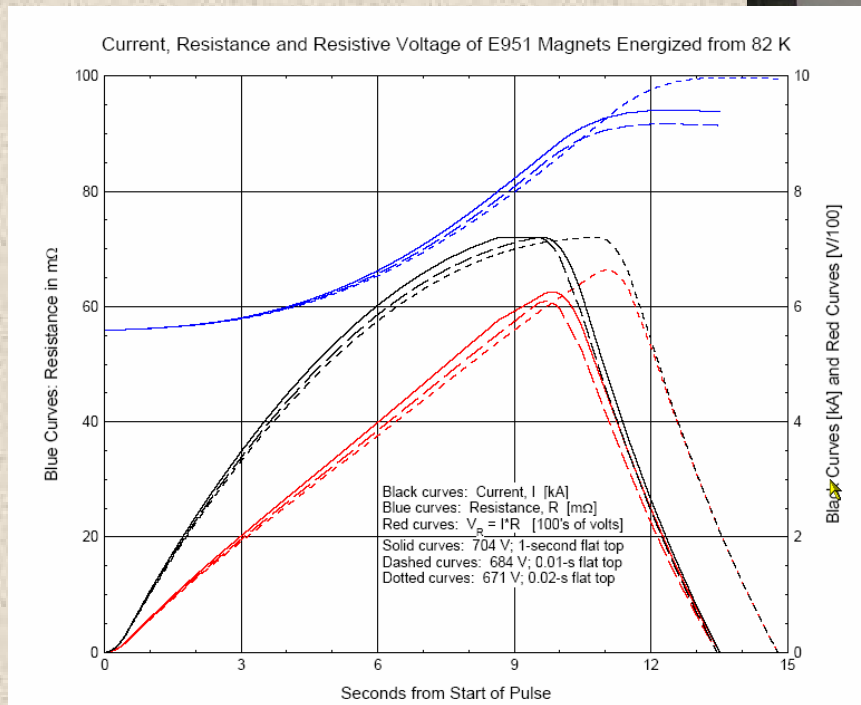


C. Martins – AB/PO

- ❑ Recuperate the power supply used for the SPS extraction to the West Area
- ❑ “pulsed” mode: 7kA / 30 min ; 5MW
- ❑ Installed in bat 193
- ❑ Cabling to TT2A during 2005-2006 shutdown – AB/PO & TS/EL

Safety issues (6/8)

Power supply



C. Martins – AB/PO

- ❑ Recuperate the power supply used for the SPS extraction to the West Area
- ❑ “pulsed” mode: 7kA / 30 min ; 5MW
- ❑ Installed in bat 193 - cabling to TT2A ongoing (AB/PO & TS/EL)
- ❑ Interlock → see later

Safety issues (7/8)

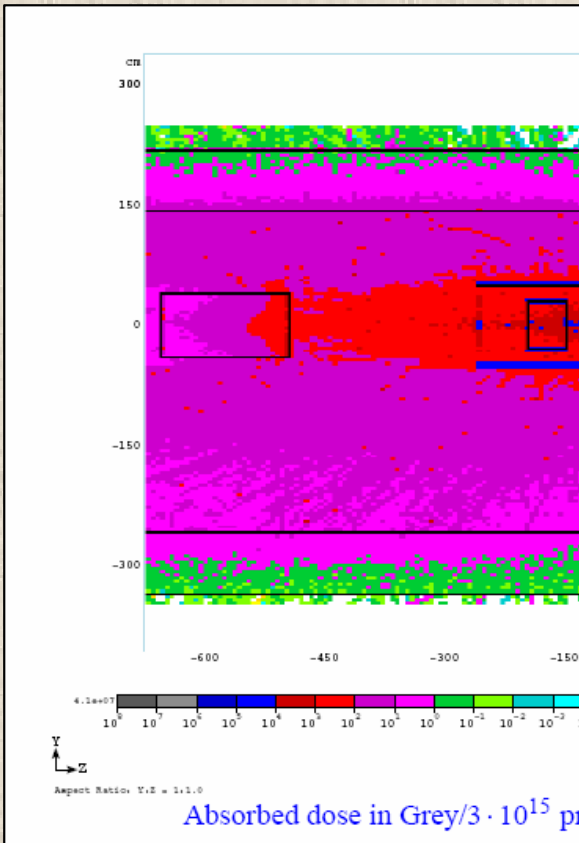
General safety

- **Magnetic field**
 - Nearby objects (Hg container) in non-magnetic material
- **Electrical safety – solenoid**
 - Connections to power cables should be protected
- **Interlock – access**
 - **Experiment:**
 - No access with magnet ON
 - Veto to power supply from cryogenics system
 - **Area:**
 - No access while handling the mercury – only specialists
 - Minimize at any time the number of people in TT2A tunnel
 - Request to modify the access to TT2/TT2A
 - Can be accessed even if beam is present in TT10 (M.Silari, T.Otto)
 - Install “normal” door, i.e. without request for RP people
 - n-TOF activated filter already dismounted

Safety issues (8/8)

Radiation environment

- Radiation issues sh experiment
- Absorbed and resid



20 September 2004
IDno2004-22m

MEMORANDUM

To: P. Cennini, DSO AB
cc: H. Haseroth, AB-ABP; A. Fabich, AB-ATB; Ch. Hill, RSO AB
From: Th. Otto, SC-RP
Conc.: Ventilation issues for Proposal INTC-P-186

Proposal INTC-P-186 (CERN-INTC-2004-016) foresees to install a Target system for a 4 MW, 24-GeV Proton Beam in transfer tunnel TT2a, upstream from the n-TOF target. An experimental campaign with not more than $3 \cdot 10^{15}$ protons from the PS on a mercury jet target is foreseen.

In principle, a target area should be equipped with a filtered and monitored ventilation system in order to reduce and to account for releases of radioactive air and aerosols into the environment.

The amount of radioactive air and aerosol produced by the the limited total beam intensity of the experiment proposed will not contribute significantly to the total releases from CERN. This circumstance allows to exceptionally deviate from the general principle.

The operation of the experiment proposed in INTC-P-186 for not more than $3 \cdot 10^{15}$ protons on target from the PS without filtered and monitored ventilation in transfer tunnel TT2a is authorised.

Thomas Otto

Th. Otto

Radiation Protection PS accelerator complex

simulations
by - FNAL



Schedule – project milestones

Magnet testing at MIT	Oct- Dec 2005	✓
Hg loop and nozzle tests at Princeton	Oct – Dec 2005	✓
Hg target loop system test at ORNL	April – June 2006	
Integration tests at MIT	Aug – Sept 2006	
Shipment to CERN	Nov 2006	
Installation preparation at CERN	<u>Shutdown 2005-2006</u> : basic infrastructure <u>Shutdown 2006-2007</u> : experiment setup	
Experiment – data taking	PS startup in 2007 (April?)	

INITIAL SAFETY INFORMATION ON

DATE: January 2006
 INSTALLATION START: February 2006
 SPOKESMAN: Harold G. Kirk, Kirk McDonald
 GLIMOS: Adrian Fabich
 FILLED IN BY: Adrian Fabich

(1) TEST BEAMS: FTN line
 LABS AT CERN (BLDG/ROOM): TT2A (FTN)

(2) GASES, LIQUIDS, CRYOLIQUIDS
 (used in detectors or kept in nee

Device type	Fluid 1 + % Fluid 2 etc.
cryogenics	LN2
hydr. fluid	???
Hg loop	mercury

(3) OTHER CHEMICALS
 Toxic/Corrosive/Flammable meta

see above,
 no flammable gases present

(4) ELECTRICITY

MAGNETS:	Magnet type	Power	Field
	BNL solenoid	5 MW	15 T pulsed

High Voltage (> 1 KV)	Detector Type	Voltage	Current
	scintillator	???	???
	not yet known	???	???

SHORT-CIRCUIT current > 5 mA for >50 V possible any
 POWER dissipated by all electronics a) on detectors
 b) off detector

SPECIAL GROUNDING REQUIREMENTS? ??? solenc

1/2

(5) LIFTING AND HANDLING

Weight of heaviest single piece to install? BNL solenoid with baseplate, ~5.5 tons
 Specially designed handling equipment? CERN standards: 170 ton crane, turtle, jacks
 For which max. weight? see above

(6) VACUUM TANK, PRESSURE TANK, CRYO TANK

Tank	Abs. pressure	Volume	Weakest part(s) of wall
LN2 dewar	2 bar	6000 liter	standard equipment
cryostat	15 bar	120 liter	(with supply lines)
Hg loop	200 bar	open system	beam windows

(7) IONIZING RADIATION

Beam intensity, radioact. Sources, depleted uranium, etc.

PS proton beam, 24 GeV/c, $4 \cdot 10^{13}$ protons/pulse, see also EDMS 626963

(8) NON-IONIZING RADIATION

	DETAILS (e.g. class of laser, origin of UV light, average power of microwaves or RF, pulsed or CW, ...)
LASER 1	class4, 808 nm, 30 W peak, 150 ns pulse, 1 MHz (2 systems)
LASER 2	class4, 850 nm, 1 W peak, micro-sec pulse at kHz (2 systems)
UV LIGHT	not applicable
microwaves, RF	not applicable

(9) OTHER HAZARDS (or remarks):

ODH, fire, access, interlocks ...

see memos at EDMS 626963, 697850, 697857, 697860

(10) RISK ANALYSIS

ODH not yet done, see also above

PLEASE RETURN THIS FORM TO THE DSO OF THE PH DEPARTMENT

2/2

Nex

Beam



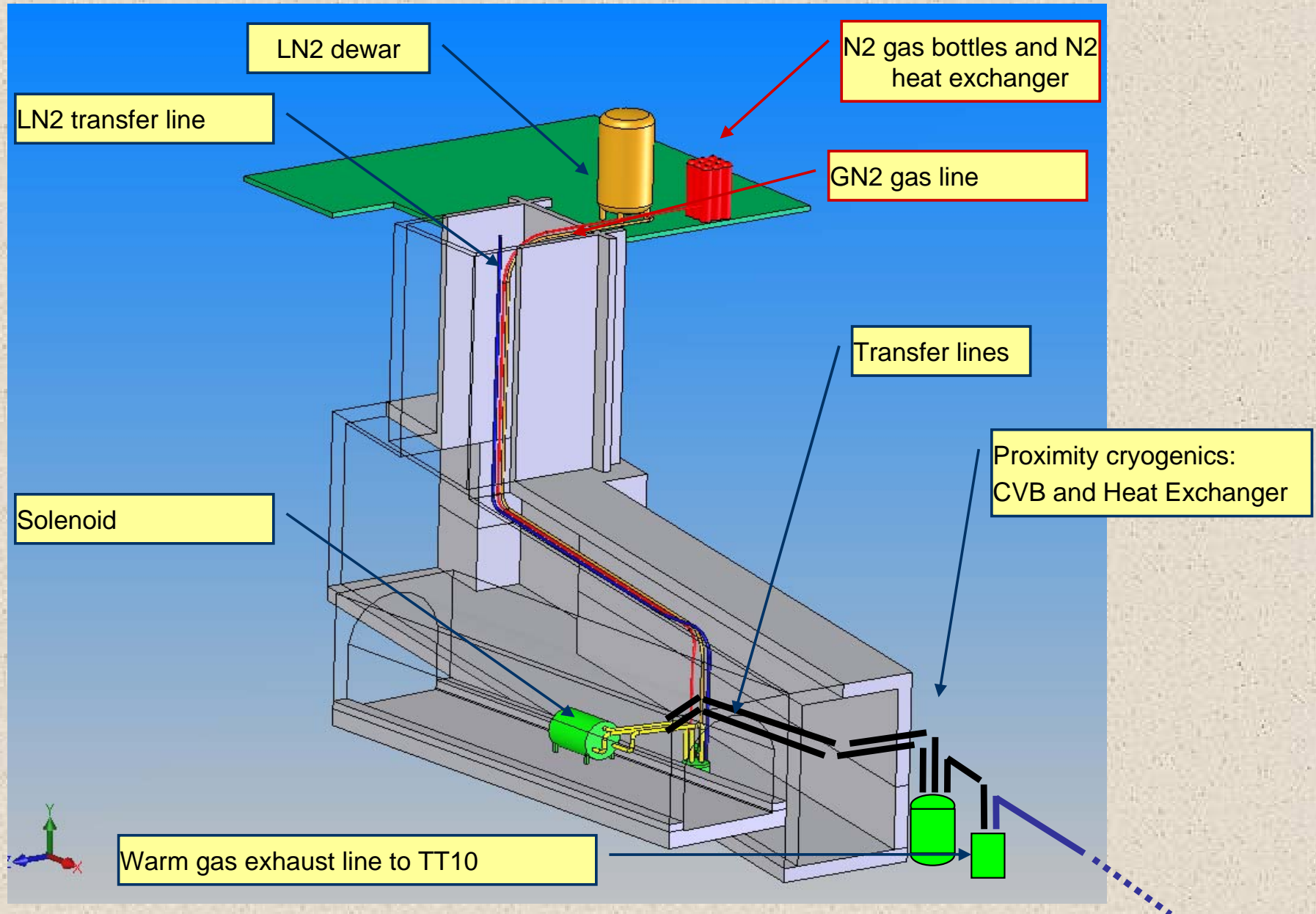
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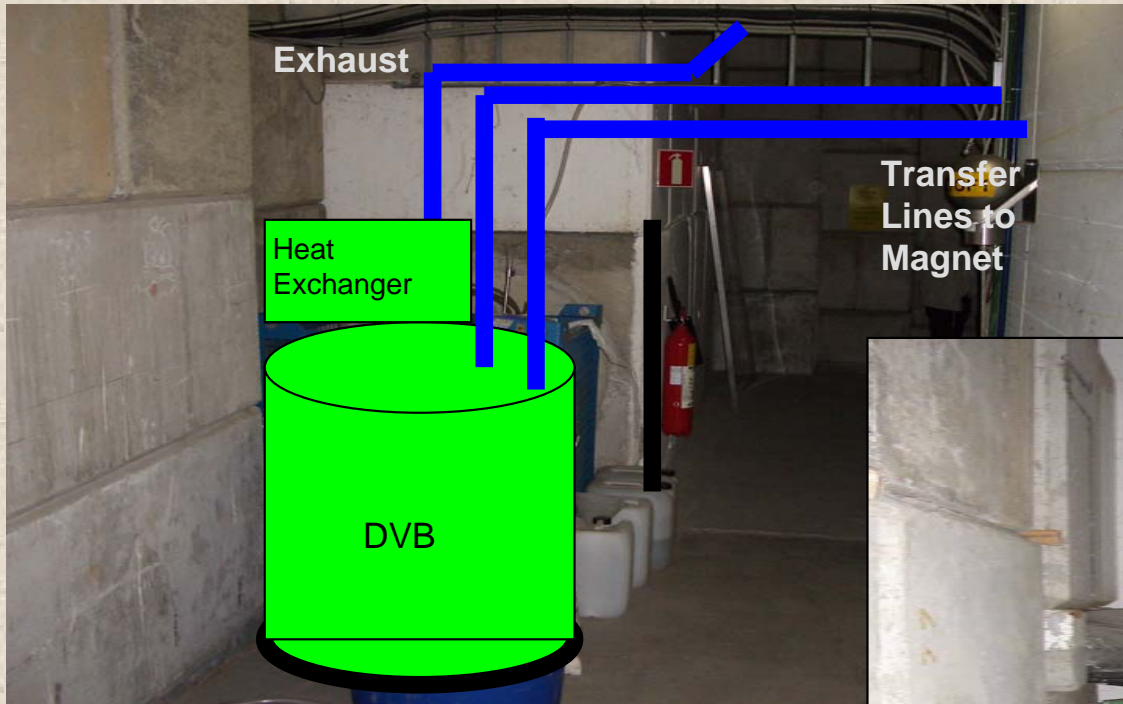
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Backup Slides

Cryogenics (1/2)



Cryogenics (2/2)



Exhaust line to TT10

- Use existing tubes to pass the exhaust line through the shielding wall
- No concrete drilling

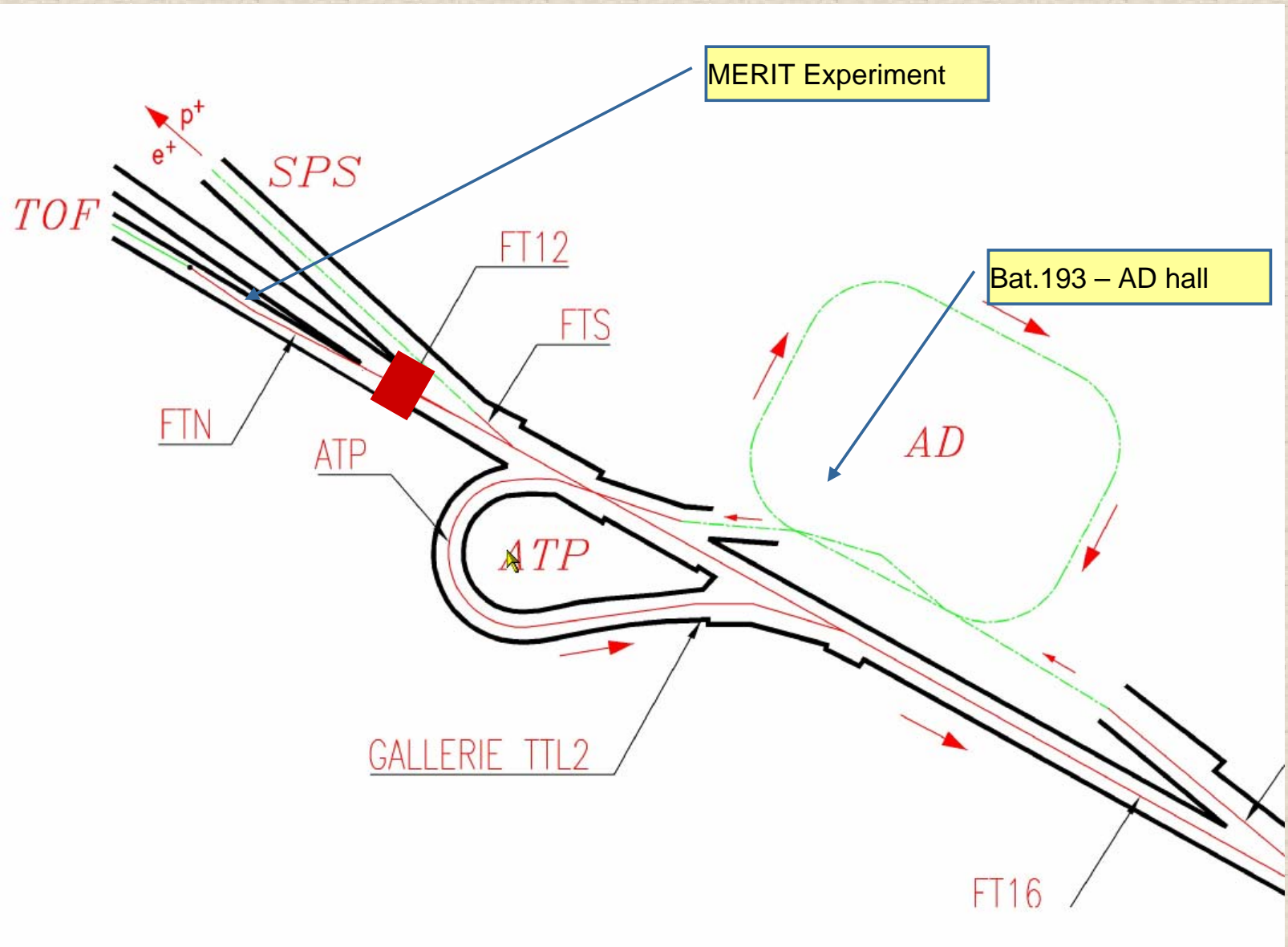


- ONLY warm N2 gas to TT10
- ~ 120'000 lt every 30 min
 - slightly radioactive: <600lt
- Exit location in TT10 still to be decided
 - Interplay between radiation and ODH risks
 - ODH detector has to be installed in TT10 and TT2

Solenoid power supply (1/2)

Installation of DC cables

- Installation
- AC
- sh
- C.I
- PS
- DC ca
- Re
-
- 3 x
- K.I
- Power
- Cr
- Ac



Other installation issues (1/1)

Experimental control room

- Use area in ISR tunnel (~40 m²) presently occupied by AT group
 - Should not be a problem, but needs to become official
 - Systems to install:
 - Cryogenics and Hg-loop control
 - DAQ and diagnostics for the experiment

FTN beam line modifications

- Liberate the space for the installation of the experiment
 - Remove few magnets and open the vacuum
- Install a new quadrupole for beam focusing onto the target
 - Magnet + power supply to specify
- Beam instrumentation to observe the beam spot at the target
 - Install a wire chamber (SEM-grid) for beam profile measurement
 - TV screen to measure the beam spot – poor man's solution

Summary

Key installation issues for 2005-2006 shutdown

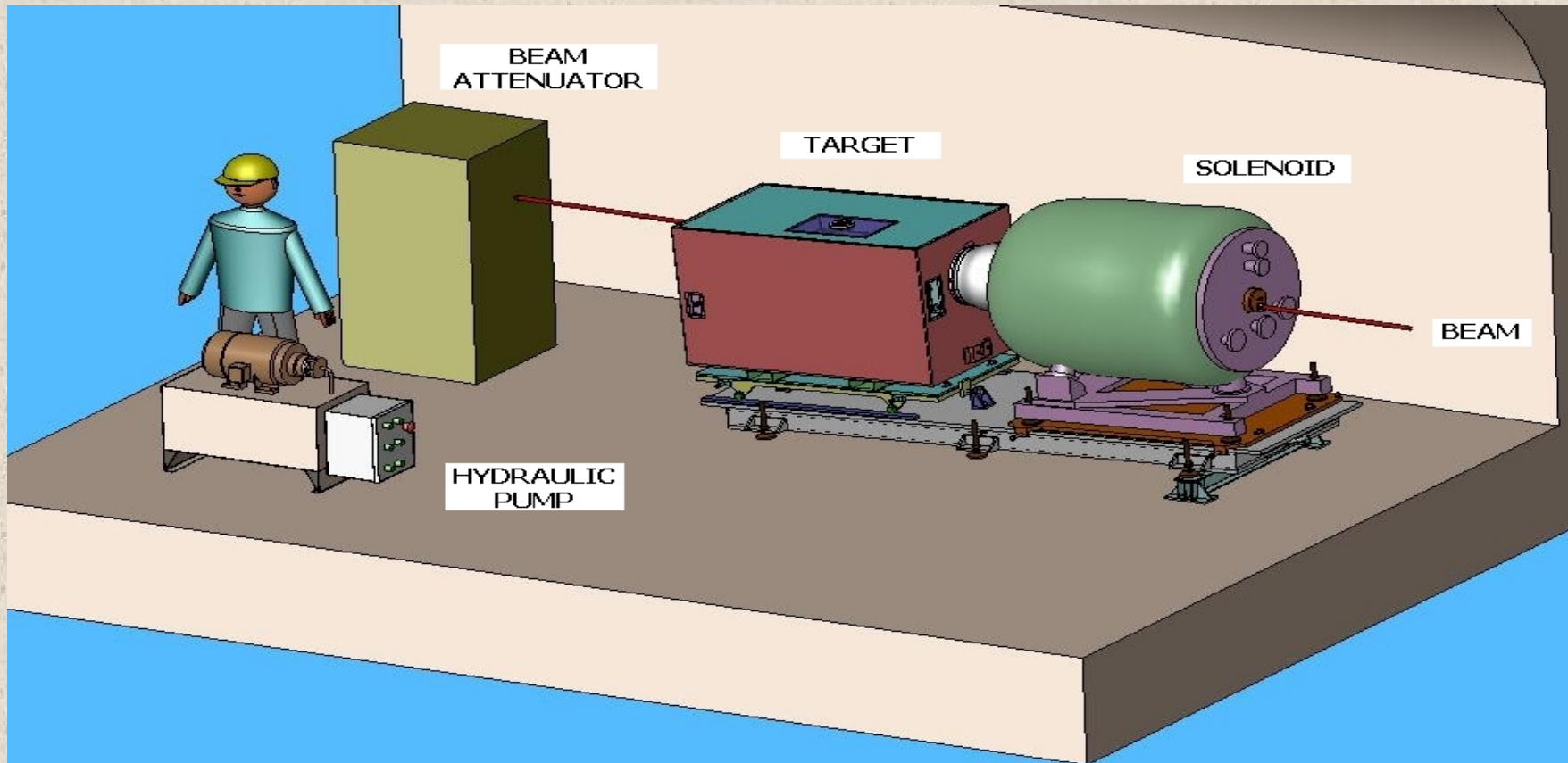
- Power supply
 - Installation in bat.193 and AC cell outside
 - DC cables to TT2A
- Cryogenics
 - Exhaust line to TT10
- General installation
 - Remove the beam elements and vacuum
 - Prepare transport tools
 - Install the beam attenuator (dump)
 - Drilling between TT2A and TT2
 - Passage of cables and fiber optics for the target diagnostics
 - Interlocks – access safety

Concentrate cabling activities in **March '06**

Installation “slot” with access to PS & SPS transfer tunnels?

Next report to ABIC: in about two months ??

The MERIT Experiment (2/2)



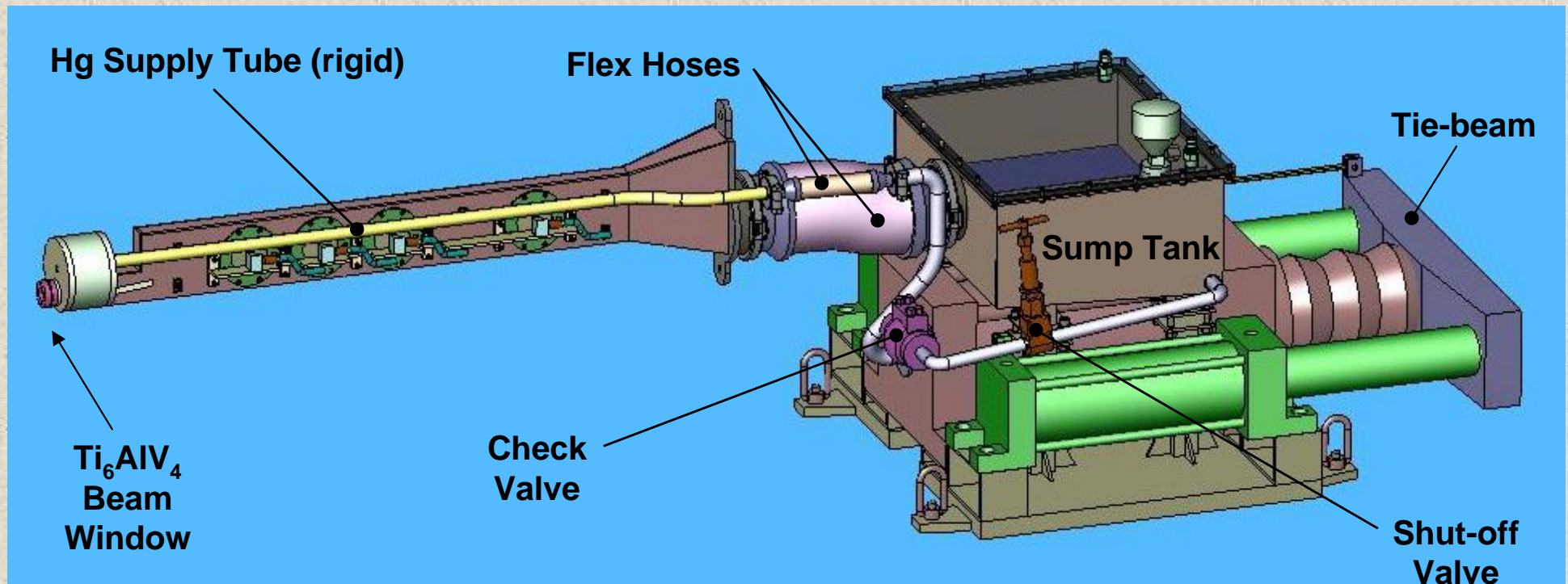
V. Graves - ORNL

- ❑ The experiment will be located in the **TT2A tunnel** upstream of the nTOF target
- ❑ **Data taking:** two-weeks at the PS startup in 2007 – second slot later as reserve

Specialties of the experiment (1/6)

Hg loop - Primary containment

- Hg delivered to the nozzle using a hydraulically-actuated piston
- Required flow: 1.57 lt/s
- Mercury inventory: ~23 lt



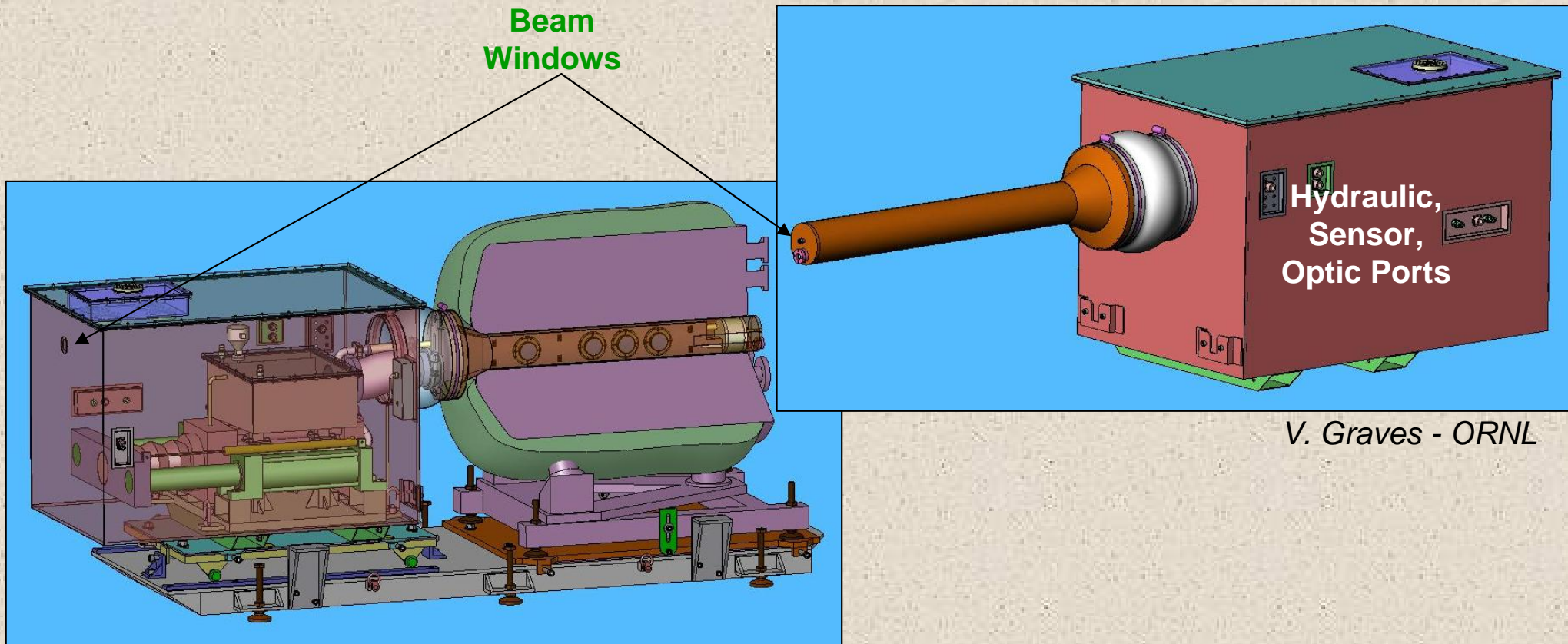
- Piston velocity : 3.0 cm/s
- Hg jet duration of 12s
- Drive cylinders: 15-cm diam, 45 lt/min, 30 MPa (300 bar)

V. Graves - ORNL

Specialties of the experiment (2/6)

Hg loop - The secondary containment

- ❑ No break of the primary container during the experiment
- ❑ All connections through the secondary containment
- ❑ Note: fringe field of the solenoid not negligible at all !!!
 - $\sim 0.9\text{T}$ at 0.5 m distance from the solenoid

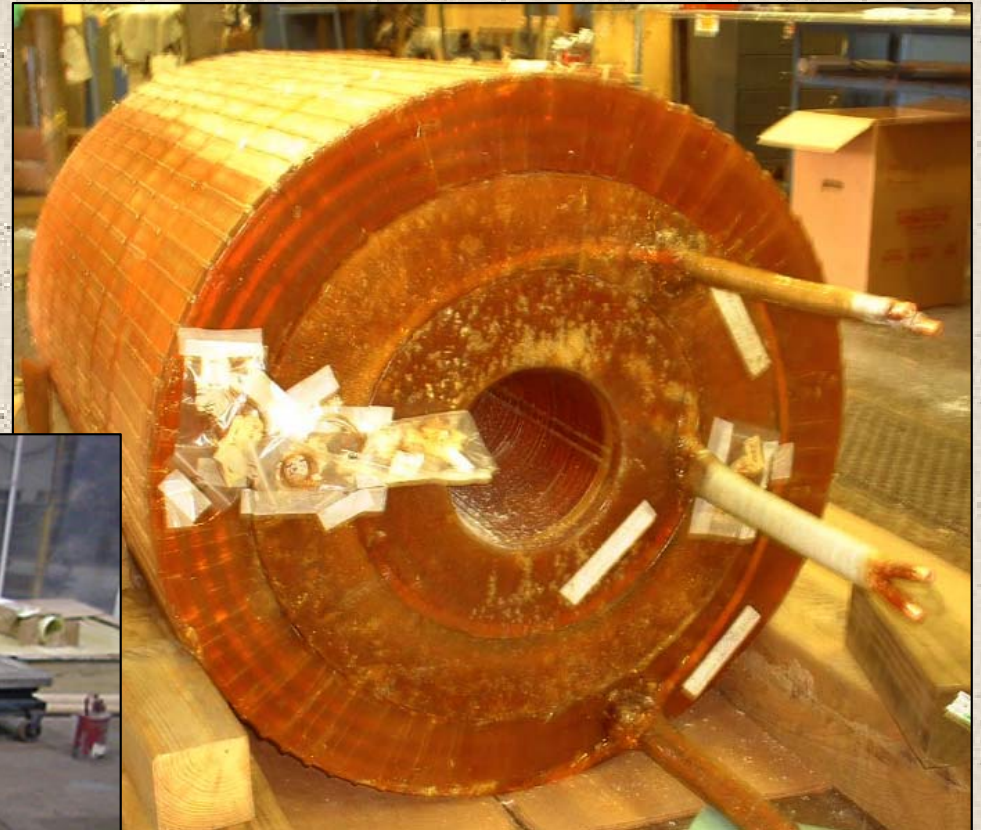


V. Graves - ORNL

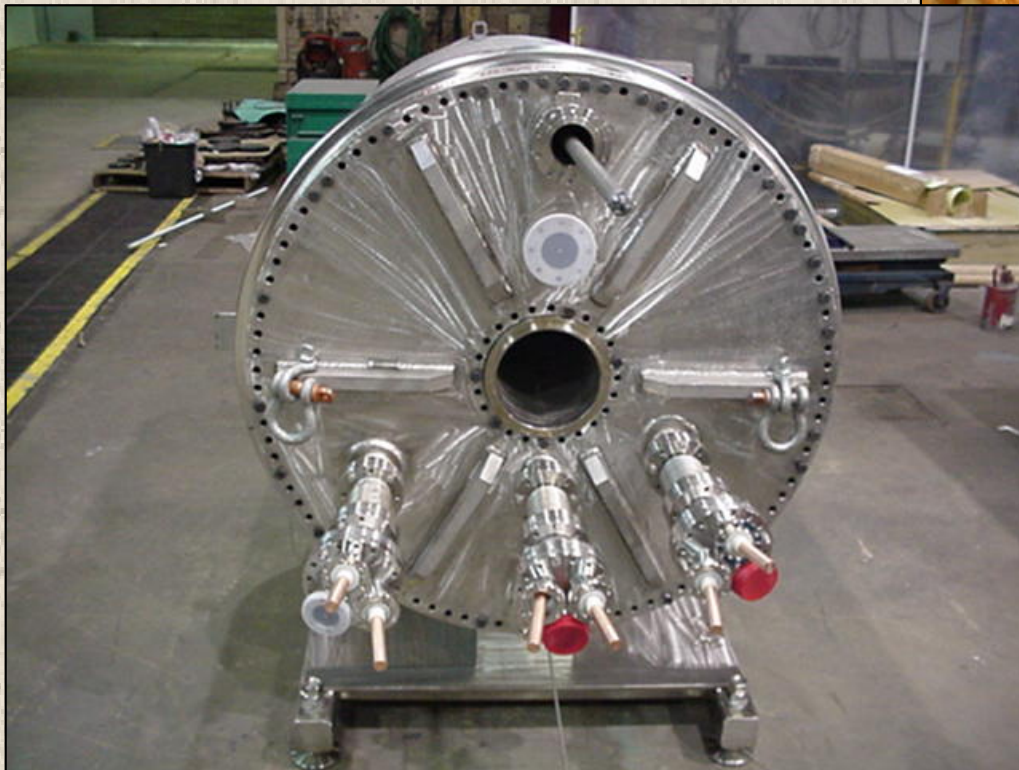
Specialties of the experiment (4/6)

Solenoid

- ❑ 15-T field
- ❑ Pulsed : 1/30min
- ❑ LN2 cooled (80K) between pulses
- ❑ Ready for tests at MIT



P. Titus - MIT



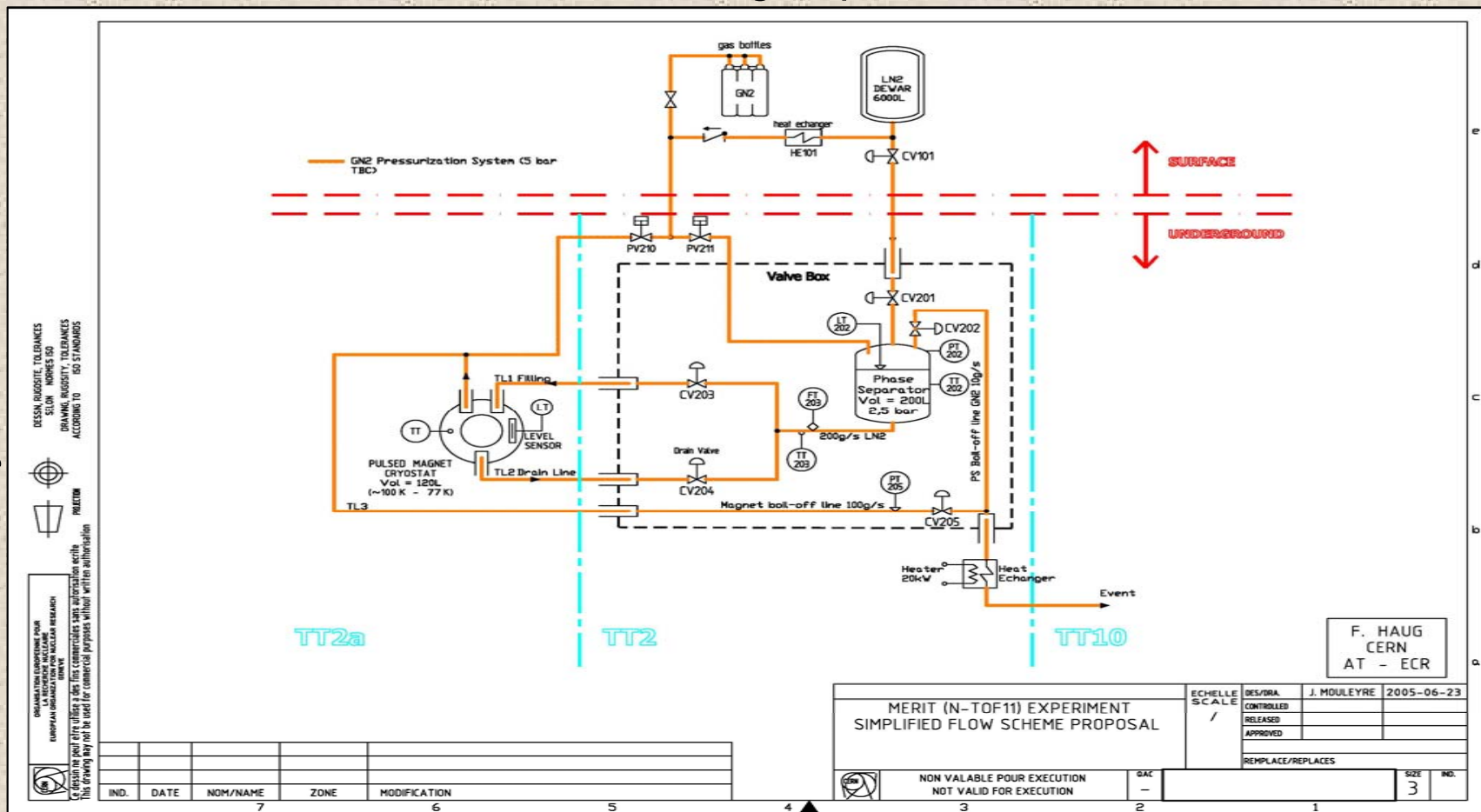
Assembled Solenoid - MIT

Specialties of the experiment(5/6)

Cryogenics

- ❑ Collaboration between RAL & CERN
- ❑ Provide LN2 to cool the solenoid at 80 K
- ❑ Readout and control from AT/ECR group – CERN standard

F. Haug – CERN
 R. Bennet, Y. Ivanyushenkov - RAL



General Layout (1/1)

